Center Independent Research & Development: GSFC IRAD

Design of Laser-Based Remote Sensing Instrument for Measuring Ocean Temperature and Salinity Depth Profiles

Completed Technology Project (2016 - 2018)

Project Introduction

We propose to design an instrument with the capability to measure both temperature and salinity profiles of ocean mixed layers. We will design the key elements of the instrument including receiver design, measurement and detection schemes, laser transmitter characteristics, and overall link margin. Our plan is to create an instrument design that can potentially measure seawater salinity and vertical temperature profiles utilizing Brillouin and Raman scattering.

The objectives of the proposed instrument design effort are as follows:

(a) Evaluating various Raman and Brillouin scattering techniques and determining how much information can likely be derived from them, and how well they could be incorporated into an aircraft instrument.

(b) Determining link margins for potential Raman and Brillouin detection schemes, and defining crucial laser parameters including pulse width, repetition rate, pulse energy, and laser wavelength.

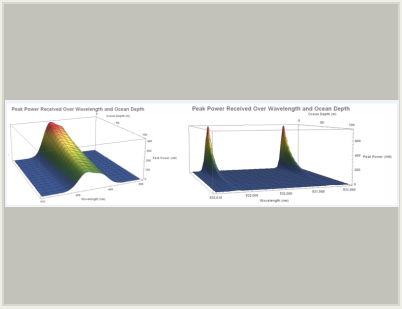
(c) Designing a receiver system that can utilize the preferred scattering detection scheme(s). Also included in receiver design are calculations of required telescope FOV, optical throughput, coupling, and detector efficiency.

(d) Design of laser transmitter & hardware to meet instrument detection scheme requirements.

The science product of the proposed instrument is vertical profiles of water column temperature and salinity with 1 m resolution obtained from collected Brillouin and Raman scattering spectra. This is an early-stage innovation that would seek further funding for hardware development at the conclusion of this design effort.

Anticipated Benefits

The proposed ocean lidar system is an early-stage innovation that would offer a significant payoff to GSFC and NASA in advancing remote sensing techniques for collecting critical ocean data, and would offer ample opportunities to partner with both public and private entities for instrument support:



Brillouin and Raman scattering link model output for the planned transmitter design

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- Temperature and salinity are two of the most important properties defining the state of seawater. Together they determine water density, which is a major factor governing the vertical movements of ocean waters and the biogeochemistry of the oceans. An instrument capable of quickly capturing vertical temperature profiles of temperature of the world's oceans would significantly advance our current knowledge of the ocean dynamics.
- Measurements of vertical profiles of temperature and salinity would also be useful in operational modeling, including for short-term prediction of weather (*e.g.,* hurricane forecasting), currents (*e.g.,* transportation and oil spills), resource mapping of biodiversity and in fisheries management, in seasonal-to-interannual forecasting (*e.g.,* El Niño), and for initializing decadal predictions of the ocean/atmosphere climate system (such as those of the IPCC).
- The proposed dual method approach allows for simultaneous measurement of both salinity and temperature as a function of water depth. Raman profiles have previously been collected as a function of ocean depth from in-situ instruments but only from very modest elevations (*e.g.,* oceangoing ship platforms). We are planning on developing an instrument that performs at a higher altitude (>150 m) that will require more innovative detection schemes but will allow for a greater coverage of data collection.

An aircraft-based instrument that could quickly and accurately obtain ocean temperature/salinity profiles would give GSFC unprecedented ocean science and modeling capabilities, and also position the center for future partnerships that could supply funding, including: the US Navy (which has an additional interest in speed-of-sound/density measurements that can be derived from Brillouin spectra), NOAA, and private entities such as nuclear power plants (verification of waste water disposal thermal models).

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

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Paul R Stysley

Co-Investigators:

Watson Gregg
Thorsten Markus
Cecile S Rousseaux

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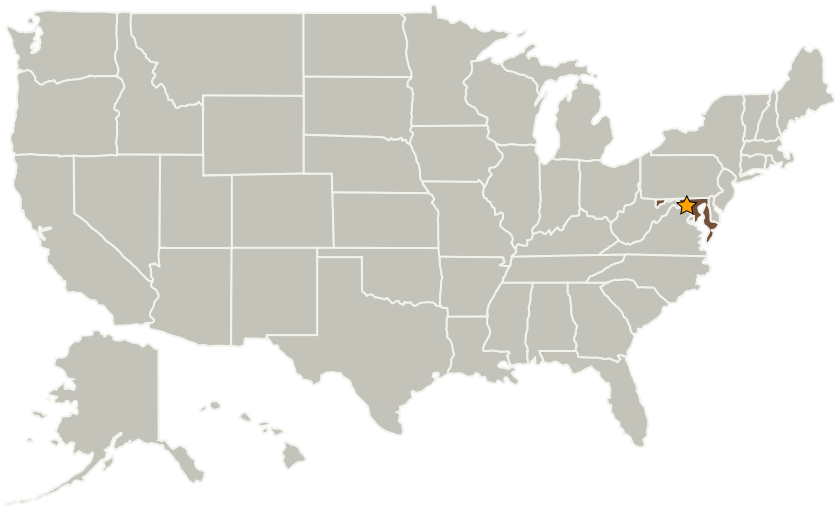
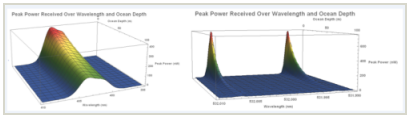
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

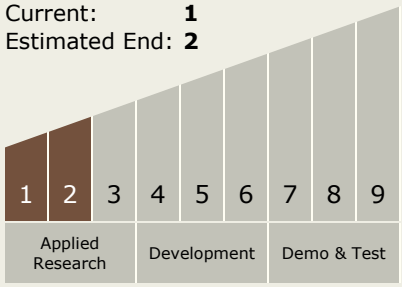
Images



Scattering link profile
Brillouin and Raman scattering link model output for the planned transmitter design *(https://techport.nasa.gov/image/27738)*

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers

Target Destination

Earth

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Project Website:

http://aetd.gsfc.nasa.gov/